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EFFECTS OF VISIBILITY ON RANGE OPERATIONS AT THE NAVAL WEAPONS --ETC(U)
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Effects of Visibility on Range Operations at the Naval Weapons Center

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by
Carl W. Koiner
Range Department

AUGUST 1979

NAVAL WEAPONS CENTER
CHINA LAKE, CALIFORNIA 93555

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Naval Weapons Center
AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

FOREWORD

This report describes the utilization of optical instrumentation systems for gathering data on a variety of weapons systems and weapon components through tests on the Naval Weapons Center ranges, and it shows the importance of this testing to the Navy's development of armament systems. The major role visibility plays in this process is demonstrated through example, and an estimate is made concerning "adequate" visibility values for range testing.

This report is a slightly edited version of the written testimony given by the author before the Energy Resources Conservation and Development Commission of the State of California prehearing conference in the matter of the Southern California Edison Company Combined Cycle Generating Station, Buttes Site, on 4 August 1978.

This report was reviewed for technical accuracy by W. T. Lamb of the Range Instrumentation Support Division.

Approved by
C. J. DIPOL, *Head*
Range Department
8 August 1979

Under authority of
W. B. HAFF
Capt., U.S. Navy
Commander

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The major role visibility plays in the production of optical instrumentation data during NWC range tests is described. As background, discussions of the NWC mission and location, test ranges and optical instrumentation systems, and workload and cost factors are presented. An example is given of the effects of changing visibility on optical instrumentation records. Finally, conclusions are drawn concerning the minimum visibility for range tests and the effects of data lost because of inadequate visibility on weapons development programs.

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A

INTRODUCTION

One of the essential activities the Naval Weapons Center performs in fulfilling its mission is the testing of weapons and weapon components on its air and ground ranges. In most range tests, key data are obtained by optical instrumentation and photographic records. Since the quality of optical and photographic data depends on visibility, it follows that the effectiveness of range testing at NWC is heavily dependent upon adequate visibility.

This report states the mission of NWC and describes the location and size of the Center. Then it briefly describes the NWC testing program and the ranges that support it. Next it describes the optical instrumentation system that is used to gather data on range tests and the workload that is presently being maintained on the ranges. It then gives an example of a series of tests that shows how the deterioration of visibility affects the quality of data that can be gathered. It also discusses the cost factors involved in maintaining the test ranges and conducting the test programs. Finally, it presents the conclusions that are drawn concerning the minimum acceptable visibility and the effects of lowered visibility on the quality of test data that are gathered.

NWC MISSION

The Naval Weapons Center (NWC), is the principal Navy research, development, test, and evaluation center for air warfare systems (except antisubmarine warfare systems) and missile weapon systems; and the Department of Defense lead agency for parachute test and evaluation. It is the Navy's largest installation for ordnance research, development, test, and evaluation. The physical resources of protected land, airspace, and environment make an ideal location for testing weapon systems and weapon components.

LOCATION OF NWC

Located in the upper Mojave Desert about 120 miles north-northwest of Los Angeles, the Center occupies more than one million acres of land lying within the counties of Kern, San Bernardino, and Inyo. About 90% of the available land is utilized exclusively for test and evaluation of weapons.

The protected airspace over NWC is composed of the restricted areas R-2505, R-2506, and R-2524, as indicated by Figure 1, and is within the R-2508 complex, which is shared by NWC, Edwards Air Force Base, George Air Force Base, Fort Irwin, and others.

NWC TESTING AND RANGES

The Center conducts a wide variety of tests in support of Navy and Department of Defense weapons programs including air, ground, track or captive testing of weapons and weapon components and propulsion and warhead testing. To accomplish this testing the Center operates a wide variety of ranges, facilities, and instrumentation and support systems.

The air test scenario, which involves air-to-air and air-to-ground missile firings, air-to-ground bomb, rocket, and munitions deliveries, aircraft weapon captive flights, and other aircraft operations, depends heavily on optical instrumentation tracking systems (and, hence, adequate visibility) for data acquisition. Air testing is accomplished principally on the Baker, Charlie, and George Ranges, as indicated by Figure 2. Also, a significant portion of the ground test scenarios require data from optical tracking systems. These tests are principally conducted in the George Range area. Optical tracking systems play an important role in parachute test data acquisitions and these operations are also conducted on the George Range.

Additionally, operations at Echo Range, located in the lower half of Mojave B, R-2524 (Figure 1), requires the use of optical tracking systems and equipments in support of many tests conducted at this activity. It is expected that this optical support will increase in the immediate future as the range is modernized and improved.

The Test and Evaluation Directorate and associated test activities at NWC has an operating budget in excess of 40 million dollars annually. The replacement value of the total Naval Weapons Center plant and property is in excess of one billion dollars.

OPTICAL INSTRUMENTATION SYSTEMS

The primary optical systems used to gather data in support of air testing at NWC are the cinetheodolite network and tracking camera mounts (TCMs).

A cinetheodolite is a camera system that records on each picture of interest the pointing angles of the camera (azimuth and elevation), the exposure time of the picture, and the target (i.e., missile, aircraft, etc.) being tracked. When the film is assessed in the data reduction process to produce time-space-position information (TSPI) on the target being tracked, the boresight or tracking error of the target from each frame of each cinetheodolite used is determined, and the raw azimuth and elevation angles are corrected to determine the true pointing angles from each camera to the target for each data frame. By a process of triangulation with a minimum of two, but usually four or more, cinetheodolites the TSPI is computed. These data from a cinetheodolite network are highly accurate, with an optimum error value of 5 feet or less in the determination of absolute space position. This highly accurate TSPI data is required for solution and description of air-to-air missile target intercepts, for determining missile or weapon performance, and to obtain weapon launch conditions.

Two types of cinetheodolites are in general use on ranges in the United States, the Askania and the Contraves. These are product names, from the Askania-Werke A.G. in Berlin, Germany, and the Contraves A.G., Zurich, Switzerland, respectively. Generally, the Contraves is a newer, more modern design, with more capabilities than Askania systems, which are not currently in production. NWC has about 65 individual Askania instruments and expects to obtain six Contraves within the next year.

Tracking camera mounts (TCMs) are tracking platforms that allow a variety of 16-mm, 35-mm, and 70-mm cameras to be pointed at a moving target of interest. These photographic records provide encounter or missile-target miss information, engineering sequential information, such as the time (to an accuracy of 0.001 seconds) of the opening of a parachute, and documentary photography. Lens systems currently in use are 44 and 88 inch focal length systems on cinetheodolites and up to 200 inch focal length systems on the TCMs.

Table 1 summarizes the types of information generally provided by optical instrumentation systems at NWC.

In support of its air and ground tests NWC presently has more than 90 permanent and temporary cinetheodolite stations, 7 permanently located TCMs, and 11 mobile TCMs. Figure 3 indicates the location of the majority of these instrument sites.

Many of the missiles and ordnance items under test on the NWC ranges are relatively small, often 5 inches or less in diameter. These must be tracked by optical instrumentation systems from distances of 10 or more miles. Figure 4 is an enlargement of an Askania 35-mm film frame. The aircraft is an F-16, and the missile (which is indistinct) is an AIM-7 Sparrow that is 8 inches in diameter and 13 feet long. The camera-to-aircraft distance is about 4 miles.

TABLE 1. Data Derived From Optical Instrumentation Records.

Information	Source
Accurate time – space – position information ...	TSPI – from cinetheodolites
Encounter or miss	From TSPI plus TCM
Engineering sequential	TCM
Documentary photography	TCM

WORKLOAD

Much of the air testing on Baker, Charlie, and George Ranges involves (1) air-to-air missiles launched from high performance fighter aircraft against full-scale and special remotely piloted target aircraft and (2) air-to-ground missile or munitions deliveries by attack aircraft against real and simulated ground targets.

With the present levels of staffing and the existing facilities, it is estimated that 3,600 hours per year of air testing time are available. During fiscal year 1978 (October 1977-September 1978), 2,100 hours of air testing were actually performed. This 2,100 hours is actual test hours. It does not include tests that were scheduled and then

postponed because of weapon or delivery aircraft failures. Past experience indicates that such failures occur about 30% of the time, because of the experimental nature of the equipment being tested. Thus to test 2,100 hours, the range must be scheduled for 3,000 hours each year, an actual utilization of 83%.

Eighty-five percent of all air testing involves the use of optical instrumentation equipment or systems. This instrumentation may range from impact spotting by three spotters or a single documentary TCM to a heavy commitment of 24 or more instruments (14 Askanias and 10 TCMs for example). About one quarter of all air tests are heavily optically instrumented; 58% of all G-Range air tests are in this category.

Thus, in summary, (1) the air test ranges are very heavily utilized; (2) optics plays a major role in the data acquisition process; and (3) there is little room or margin for arranging or optimizing the optical coverage or test times, when required, by preferential or special scheduling procedures.

AN EXAMPLE OF THE EFFECTS OF CHANGING VISIBILITY ON OPTICAL INSTRUMENTATION RECORDS

Three identical tests of an air-to-ground missile system (a Walleye Missile, 12-14 inches in diameter) were made on April 10, 11, and 13, 1978. The tests occurred on G-Range; the test layout is indicated in Figure 5. Seven Askanias and 4 TCMs were used each day. The tests occurred at 9:45, 9:49, and 10:19 PST respectively. Visibility as measured on G-Range at those times were 100, 45, and 33 miles. Visibility values were derived from data obtained from Meteorology Research, Inc., Integrating Nephelometer, Model 1562, located at Tower 3 on G-1 Range. Figure 6 shows the missile at launch, in flight with a sky background, and near impact with a mountain background for each test (April 10th on top, April 11th center, April 13th on bottom; sequence is from right to left). It is clear that conditions deteriorated optically over the series, and the records from 13 April are marginal. In fact, a requirement for high quality documentary photography could not be met because of these conditions. It can be stated that visibility values around 30 miles as experienced during this last test are an absolute minimum acceptable value. Further reductions in visibility would result in data loss from the optical instruments used. A test of a smaller missile (for example, Sidewinder, 5 inches in diameter) would not be possible with 30 mile visibility conditions, since the data loss would be more extensive than in the foregoing test example.

COST FACTORS

The cost of a heavily instrumented test on an NWC range falls between $10,000 and $50,000, depending on complexity and on equipment and services required. Even

greater costs lie in the experimental hardware tested and the monetary effect on a missile program. The prototype missile systems tested in the initial phases of a development program may represent hundreds of thousands of dollars. A loss of data at a critical time in a program may cause delays or realignments which amount to millions of dollars. The initial loss of $50,000 in range costs is often a minor part of the total effect on the overall program.

Instrumentation support could be increased to make up for coverage lost by restricted visibility. While sufficient instrumentation to increase the coverage is available presently at NWC, staffing levels would have to be increased at an annual operating cost of several hundred thousand dollars each year. This, however, would not give complete assurance of 100% optical coverage on every test, since no amount of increased coverage can fully compensate for poor visibility.

CONCLUSIONS

Optical instrumentation systems play a vital role in the data gathering process on the NWC air test ranges. These ranges are so heavily utilized that there is little room for arranging the schedule to optimize optical instrumentation coverage on those tests requiring its use.

Present conditions (30+ miles visibility on some occasions) is an absolute minimum value for the larger missile systems presently under test. Even so, data is sometimes lost. For smaller missiles more visibility would be required to insure no data loss. Perhaps 40-50 miles measured visibility would be needed to cover all missile and ordnance systems of the types currently under test at NWC without jeopardizing results or significantly increasing test costs.

While test costs are substantial, the greatest financial loss when data is lost because of poor visibility is in the downstream effects on the overall weapon system program. Here the costs from lost data and tests can account for millions in lost time and hardware expended without results.

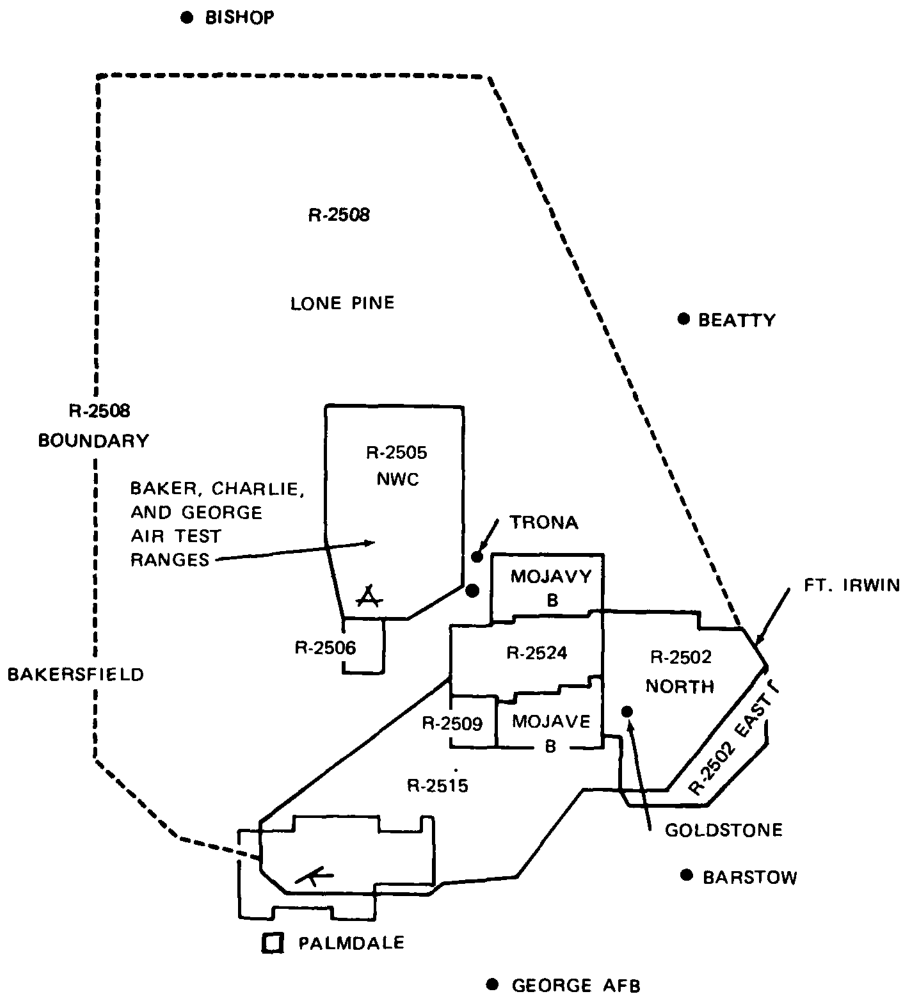

FIGURE 1. R-2508 Complex Airspace.

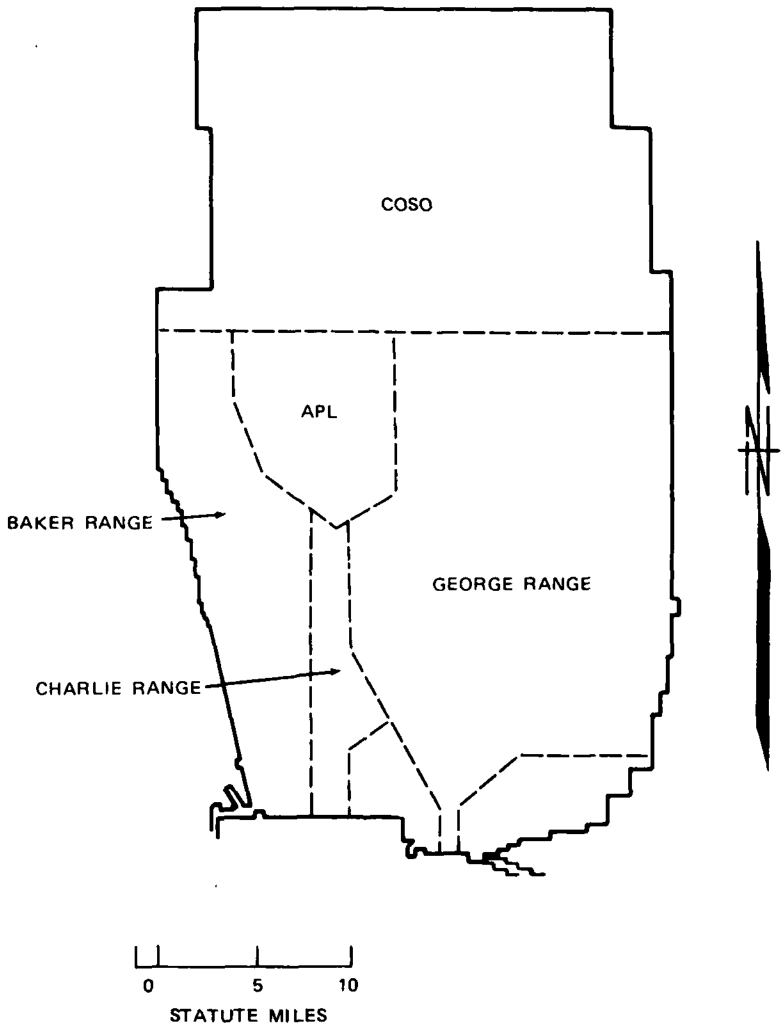

FIGURE 2. Air Test Range Areas.

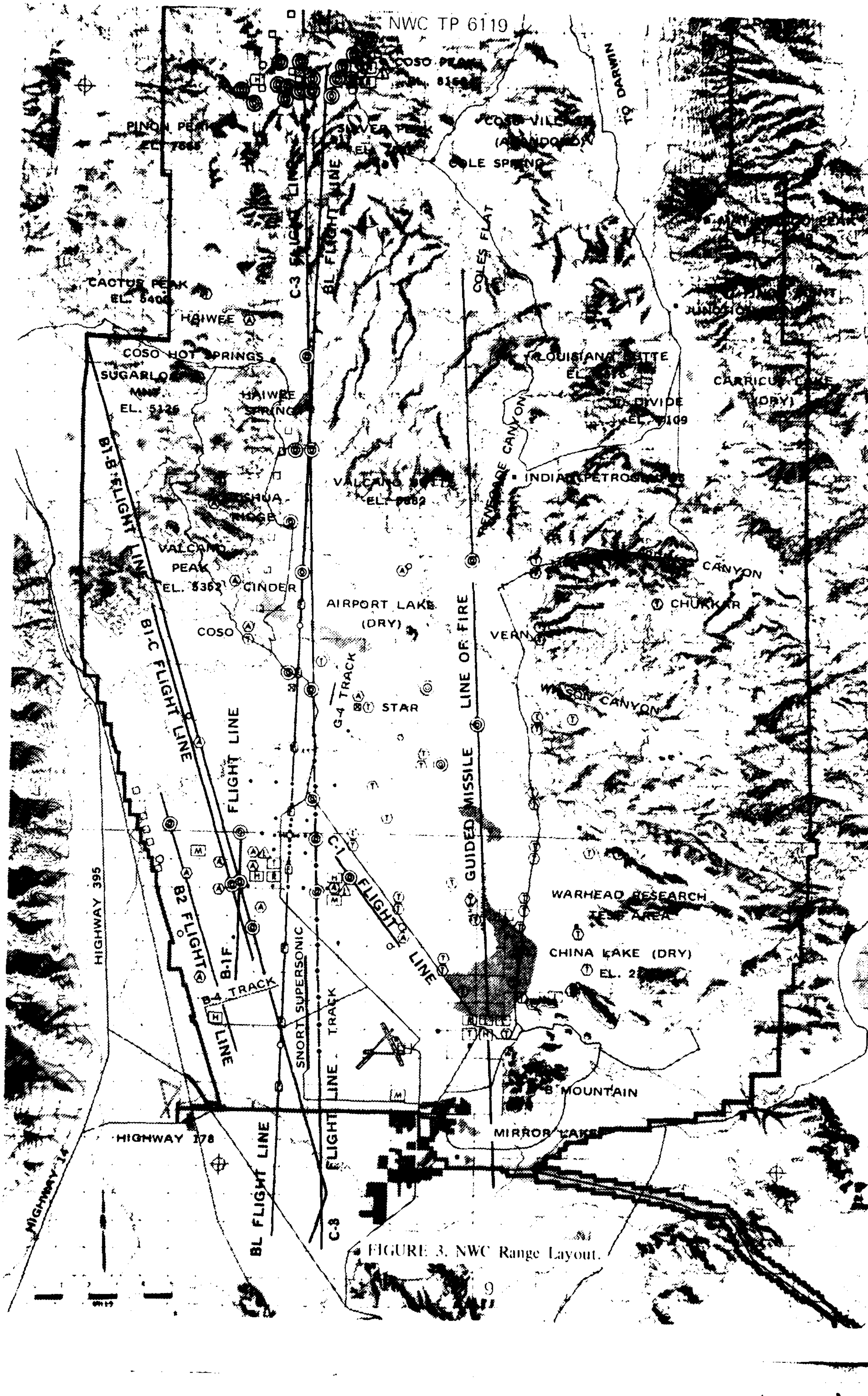

FIGURE 3. NWC Range Layout.

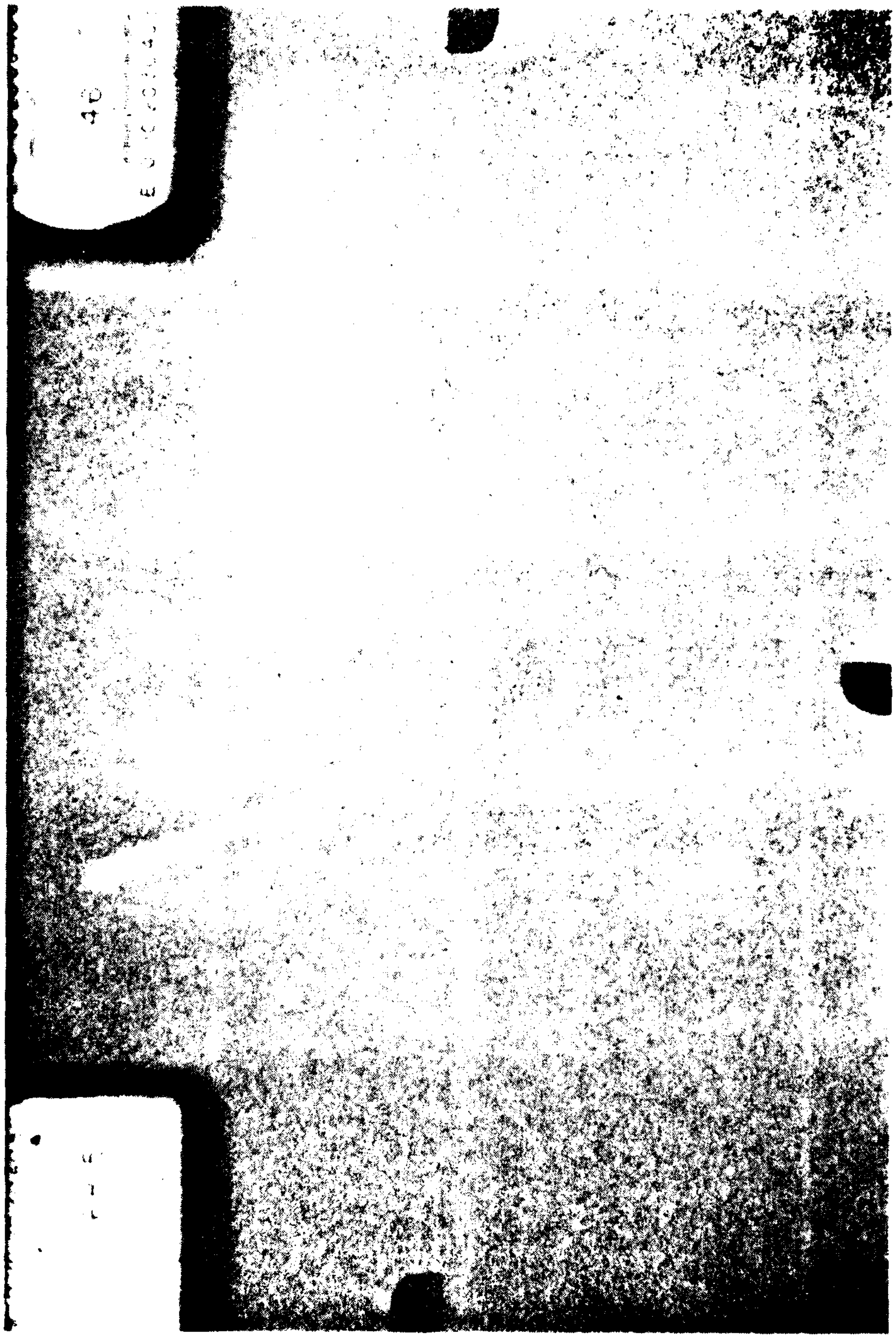

FIGURE 4. F-16/AIM-7 Askania Cinetheodolite Frame.

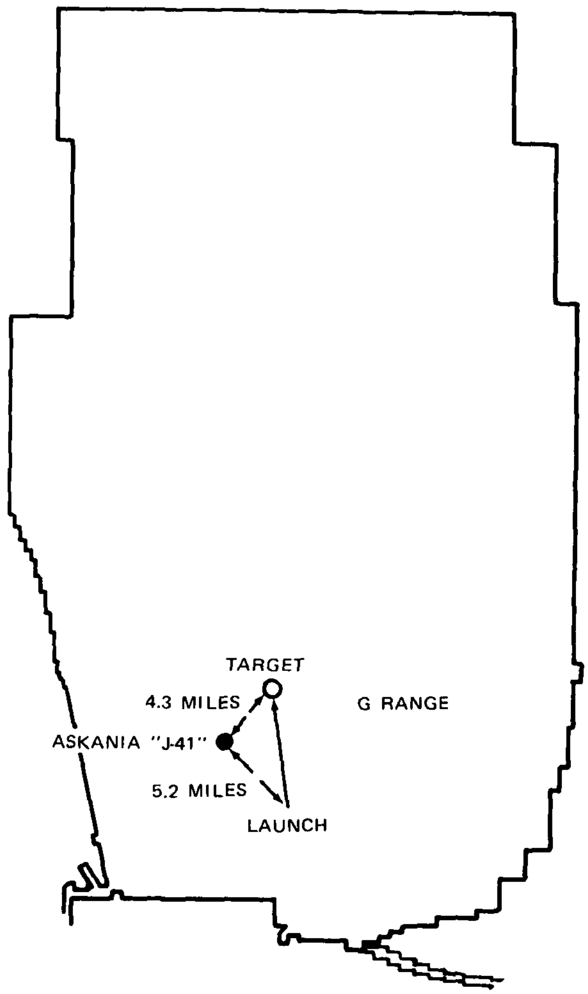

FIGURE 5. Walleye Test Layout.

FIGURE 6. A[illegible] Ground Missile Tests

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